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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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University of Pittsburgh

WESTERN PSYCHIATRIC INSTITUTE AND CLINIC

JOB COMPLEXITY AND COGNITIVE PERFORMANCE

IN BANK PERSONNEL

Harold W. Gordon

Martin P. Charns

Barbara W. Garamoni

Western Psychiatric Institute and Clinic

University of Pittsburgh

&

School of Management

Boston University

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3811 O'HARA STREET, PITTSBURGH, PA. 15213

ABSTRACT

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Job Complexity and Cognitive Performance

in Bank Personnel

Performance on visuospatial skills associated with specialized function of the right hemisphere has been shown to predict success in combat pilots (Gordon et al, 1981). The notion that visuospatial functions might be better performed by artists, and verbal functions might be better performed by lawyers is generally borne out in testing (Arndt and Berger, 1978) even though individuals in these diverse occupations do not show left/right differences in brain activation (Dumas and Morgan, 1975, Arndt and Berger, 1978). Unfortunately, in spite of the empirical support for some obvious occupations, more subtle implications of cognitive preference in most occupations have to be validated in their own right. This study is a first attempt in this direction.

Thinking processes associated with the right hemisphere are characterized as "diffuse" (Semmes, 1968), "global" and "parallel" (Cohen, 1973). We have hypothesized that for the business world, such broad thinking would be associated with jobs that are comprised of interconnected duties or tasks. "Interconnectedness" implies that performance of one task that influences or is mutually dependent upon performance of another task. A "global thinking style" should be useful for keeping track of many different projects and ideas, as well as their mutual interactions, at one time. To test this hypothesis, an objective scale of job complexity was developed (Charns and Schaeffer, 1983) to which assessment of cognitive abilities (Gordon, 1983) may be compared. Individuals who hold the most complex jobs would be expected to have greater ability in tasks associated with the right hemisphere, such as 3-dimensional perception and other spatial manipulations. Their particular

duties should have less importance, theoretically, than the number and complexity of these duties. Exceptions would be specialized jobs such as sculptors, jet pilots, and perhaps computer programmers, because the cognitive skill neded for the type of job is likely to confound the complexity issue.

For this study, it was convenient to select the Human Resources Department of a local bank in which there were clerical staff and secretaries as well as middle managers. An overall bias toward left hemisphere, verbal/ sequential functioning might be expected in the department as a whole, but the more complex jobs should be held by individuals who have greater visuospatial ability.

<p align="center">Method</p>

Subjects

Twenty-three employees of a Human Resources department at a major bank in the Pittsburgh area were tested with the Cognitive Laterality Battery (CLB) to determine the cognitive profiles of job holders. In addition, job descriptions and job analyses were completed on 4 male and 16 female employees for a final sample of 20.

Instruments

The Cognitive Laterality Battery. The Battery consists of eight tests and, along with instructions, is presented on 35mm slides together with audio cassettes. The subjects observe or listen to the stimulus presentation and respond on special answer forms passed out for each test. The tests had been chosen to reflect the visuospatial and verbal/sequential functioning of the right and left hemispheres respectively. Factor analyses on the normative population confirmed the qualitative, orthogonal differences between the function types.

The tests were administered in a fixed order alternating according to factor type. The following is a description of the tests in the order presented:

(1) Serial Sounds: A total of 12 sequences of 4, 5, 6 and 7 familiar sounds (e.g., baby, bugle, rooster, bird, telephone, etc.) were played from a pre-recorded tape. The subject's task was to write the items in the same sequential order. The onsets of each sound in the sequence were spaced at 2-second intervals. The subject waited for a start signal at the end of the sequence before the answer. Scoring was based on the number of items correctly reported in sequence whether or not the whole sequence was correct.

(2) Localization: A photographic slide containing a black "x" within a black frame on a white background was flashed on a screen for 3 seconds. The subject had a similar frame on the answer sheet and marked with a pencil the location of the "x" within it. There were 24 slides arranged in pseudorandom order counterbalanced such that the same number of "x's" appeared in each of the four quadrants. Subject's score was the total error in millimeters accumulated over all trials. (This was the only test in which a high score represented a poor performance).

(3) Serial Numbers: A total of 9 sequences of 4, 5,...9 single digit numbers were presented at a rate of 1 per second. At the end of each sequence the subject was required to write the sequence in the same order as presented. The scoring was the same as Serial Sounds in which partial credit was given to correct fragments of sequences even if the whole sequence was not correct.

(4) Orientation: (Adapted from Shepard and Metzler, 1971). The stimulus was a slide of 3, three-dimensional, S-shaped constructions

of 10 stacked cubes. Two constructions were identical but rotated in space around a vertical axis. The third was the same as the other two but appeared as the mirror image. The subject was given 15 seconds to select the two constructions that were alike. There were 24 trials.

(5) Word Production, Letters: The subject was given one minute to write as many words as possible, beginning with a given letter of the alphabet. The subject's score was the total of three attempts, each time with a different letter.

(6) Word Production, Categories: The subject listed as many animal and food names as possible. One minute was allowed for each category. The subject's score was the total of the two categories.

(7) Form Completion (Closure Speed): (Adapted from Thurstone and Jeffreys, 1966; French, Ekstrom, and Price, 1963). The stimulus was a slide containing 6 incomplete silhouette drawings of common objects or scenes appearing white on a blue background. The items were selected from two similar tests and chosen to be as culture-free as possible. The task was to identify and describe, in a word or two, each of the 6 drawings. Forty-five seconds were allowed for each slide and answers were written on special answer sheets. Six slides were presented for a total of 36 items.

(8) Touching Blocks: (MacQuarrie, 1953). The stimulus was a slide of one large cube construction made up of 8-10 stacked rectangular blocks. The blocks were stacked such that anywhere from 2 to 8 blocks were adjacent to (touching) any one block. For each stimulus slide, 5 of the blocks were numbered and the subject was given 45 seconds to indicate the number of touching blocks for each of the numbered blocks. There were 6 slides for a total of 30 items.

Analysis of performance on the Cognitive Laterality Battery. Standard scores were calculated on the basis of means and standard deviations of 250 adults drawn in part from a non-college population and in part from an under-graduate and graduate student population. The scores were derived separately for males and females. Mean scores for the two main factors were calculated by averaging the standard scores for the visuospatial tests (called A after "Appositional" (Bogen et al., 1972) and verbal/sequential tests (called P after "Propositional"). A cognitive profile called the Cognitive Laterality Quotient (CLQ) is defined by the difference between the two averaged scores: CLQ = A-P. For a "normal" subject, CLQ = A=P=0, by definition since all are linear combinations of standard scores. When CLQ>0, the visuospatial tests are performed better; when CLQ<0, the verbal/sequential tests are performed better.

The CLQ is the dependent variable that defines the relative processing efficiency of brain functions as determined by the CLB subtests. A measure of overall ability can also be obtained by averaging the two averaged cognitive measures: Cognitive Performance Quotient, CPQ = (A+P)/2.

Job Description and Job Analyses. In order to determine the number of elements contained in a specific job and the nature (and number) of inter-connections between the elements, the following steps were taken:

(1) Job Description Rating: A job description was first obtained for each employee from the supervisor. In an interview, this supervisor defined the various elements that make up a particular job, e.g., among the elements in combat piloting are (a) attaining proper altitude, and (b) attaining proper air speed. The supervisor was then asked to rate each job element on its importance within the

total job using a scale of 1 to 7 (1= of minor importance to job; 7
= of extreme importance to job). A standardized description sheet
was used (see Appendix A).

(2) Supervisors were then asked to fill in a triangular matrix (see
Appendix B) defining the "interconnections" between job elements.
Interconnections were defined as:

     0 = No connection between job elements; i.e., Element X has no
       effect on performing Element Y.

     1 = Sequential dependence of job elements; i.e., Element X
       influences Element Y but not the reverse (X-->Y).

     2 = Reciprocal dependence of job elements; i.e., Element X
       influences Element Y and, at a subsequent time, Element Y
       influences Element X (X$\overset{\text{-->}}{\underset{\text{<--}}{}}$Y).

     3 = Simultaneous interdependence; i.e., Element X and Element Y
       influence each other dynamically (X<-->Y).

(3) Performance Rating: In the final step, the supervisors were asked
to rate the job holder's performance for each element. This was
accomplished by placing an "x" along a line in the location that
best described performance. End points of the line were defined
as "Worst Possible Performance" and "Best Possible Performance."
A score was obtained by measuring the distance in cm. from the left
endpoint. (see Appendix C). An overall performance rating was then
obtained for the job as a whole using the same line scale.

Measures

Two types of complexity measures were developed from the job description
data obtained from supervisors. The first type was job _scope_, computed as the
number of elements per job. The second type was _interconnectedness_, for which

there were the different degrees described above: "simultaneous", "sequential", and "reciprocal," as well as "none" (no interconnections). It was intended that the number of higher order interconnections between elements would provide a first approximation to the actual job complexity. The more elements, the larger the job; but also the greater the degree of interconnectedness, the more complex the job. The variables, then, were the numbers of Simultaneous, Reciprocal, Sequential and Null connections.

Since the number of interconnected pairs of a job is dependent on the job scope, (the total number of job elements), jobs with a larger scope would have more pairs of elements and therefore more complex elements just by virtue of their size. Accordingly, Indices of Complexity were defined by the ratio of each degree of interconnectedness to all possible interconnected pairs. For example, the Index of Simultaneous Complexity would be the number of simultaneous interconnections (i.e., number of 3's) divided by the number of all possible connections (i.e., pairs of elements) (0's + 1's + 2's + 3's).

The number of interconnections also does not capture the qualitative difference between two characteristically different types of jobs having the same numbers of interconnections: 1) jobs where one or two elements were highly interconnected with other elements, compared to 2) jobs where interconnections were distributed more homogeneously across all possible pairs of elements. To assess this difference, an Index of Complexity for Complex Elements (ICCE), was created. For this Index, the 4 most complex elements were selected. Complexity was defined by computing the ratio of Simultaneous, Reciprocal and Sequential interconnections to the total number of possible interconnections in each element (1's + 2's + 3's)/(0's + 1's + 2's + 3's). To get an ICCE the 4 highest ratios were averaged and compared to a similar average ratio for all the elements together. An ICCE of 1.0 would by

"perfect" homogeneity--the 4 most complex elements are just as complex as the rest. Jobs in which some of the elements were highly complex would have ratios greater than 1.0.

Finally, none of the above measures account for the fact that some elements are more important for job performance than other elements as determined by supervisor ratings. Accordingly, an Index of Complexity for Important Elements (ICIE) was calculated in the same way as the ICCE except that the average of the 4 most important elements were taken as the numerator of the Index ratio rather than the 4 most complex. The 2 indices would be identical if the most important elements were also the most complex. There is also the possibility that the Index of Complexity for Important Elements could be less than 1.0.

Results

Visuospatial skill is positively related to job scope -- the total number of job elements -- of the job ($r = 0.49$, $p < 0.05$) (See Table 1). This means that job holders with the highest ability to perceive and remember points in space, visualize in 3-dimensions, and imagine completed shapes were also those that had acquired the jobs with the greatest number of different tasks. By contrast, verbal/sequential skills were not related to the number of job elements ($r = 0.02$). In other words, job holders had attained more complex jobs whether or not they were verbally fluent or had good sequential memories for sounds or numbers.

-- Place Table 1 about here --

The same significant relationship between visuospatial skills maintained for the number of the most complex (Simultaneous) interconnections, but not for the other interconnections. For the Simultaneous connections, $r = 0.43$ $p < .06$); for the Reciprocal, Sequential and Null connections, r's were less than 0.20. However, this result may be artifactually related to the somewhat

smaller number of Reciprocal and Sequential interconnections. There were 50%-100% more Simultaneous connections than Reciprocal or Sequential, while the number of Null connections was about twice that of the Simultaneous connections.

The unequal number of interconnections suggests a problem. There is no assurance that supervisors were able to distinguish clearly between the 3 types of higher-level interconnections. Not only did the job elements themselves have ambiguous relationships but the criteria were not always easily applicable. If the data are reanalyzed such that the Reciprocal, or the Reciprocal and Sequential, interconnections are included together with the Simultaneous interconnections, the interaction between two job elements would be dichotomized to be either "complex" or "null". This redefinition of complexity improved the correlation between visuospatial skills and the number of interconnected job elements. (See Table 1) The correlations with Simultaneous + Reciprocal, and with Simultaneous + Reciprocal + Sequential were $r = .43$ and $r = 0.48$, respectively. By contrast, correlations between the number of Null connections and visuospatial skills was small: $r = 0.15$.

The significant correlations with visuospatial skill were also found for the number of complex connections of the 4 most important job elements. The ranking for importance of each had been performed previously by the supervisors. The correlations between the numbers of complex interconnections (i.e., number of 1's + 2's + 3's) and visuospatial skill were 0.54, 0.63, 0.60, and 0.54, for the first 4 important elements, respectively. (See Table 2) The correlations between visuospatial skills and the number of Null interconnections averaged about -0.12. This means that for the most important elements of the job, the relationship between visuospatial skills and complexity is even stronger than for the measures of complexity of the job as a

whole. For all these connections, the correlations with the verbal/sequential skills were still small.

-- Place Table 2 about here --

Another way to measure complexity is by an Index of combined Complexity defined by the ratio of complex interconnections to the total number of inter-connections: (1's + 2's + 3's)/(0's + 1's + 2's + 3's). The larger the IC, the greater the number of job elements that have complex interactions. The converse is that jobs with a low IC are those which have a lot of duties (elements) that are not connected with one another.

Correlations between visuospatial skills and the IC's are positive but not significant as they had been between visuospatial function and the total numbers of complex interactions. (See Table 3) However, there were positive and significant correlations between the IC's and verbal/sequential skills where there had been no correlation between numbers of connections and verbal/sequential skills in the previous analyses. Apparently, the Indices of Complexity were highly correlated with overall performance (visuospatial plus verbal/sequential skills) on the Cognitive Laterality Battery.

--Place Table 3 about here--

There was no relationship between specialized cognitive performance and jobs that had a concentration of complex rather than a homogeneous mix of complex elements. Nor was there a relationship between specialized cognitive function and jobs in which the more complex elements were the more important elements. This simply means that jobs with "hetergeneous" complexity defined by the Index of Complexity for Complex Elements (ICCE) or by the Index of Complexity for Important Elements (ICIE) were not particularly related to specialized cognitive function.

Discussion

The significant relationship between visuospatial skills and job com-
plexity encourages the view that specialized cognitive functions of the brain
are related to success in managerial positions with respect to the complexity
of the duties. This conclusion is based on the assumption that in the popu-
lation studied, individuals were hired or promoted to their particular jobs
because of recognition of their skills by management. This assumption is not
unreasonable since performance ratings were invariably high suggesting satis-
faction by management that their choices had been accurate. (The performance
ratings had been made confidentially without benefit or detriment to the
employee.)

A second possibility cannot be ruled out. More individuals who already
had preference for right hemisphere skills could have been attracted to the
more managerial positions or complex job duties. In other words, it is pos-
sible there was a self selection process. However, by whatever method --
undoubtedly subjective -- the persons most skilled in locating points in space
or imagining objects in three dimensions were hired, promoted or chose jobs
requiring many different tasks, especially those that were mutually inter-
active.

At first glance, it would seem unusual for an employer to hire or promote
someone based on their better ability to visualize cube configurations than to
remember sequences. A closer look at the theoretical basis of such a decision
lends some support to the idea. The results of this study suggest that the
common factor of performing well both on visuospatial tasks and in complex
jobs is that both require specialized cognitive functioning associated with
the right cerebral hemisphere. The positive correlations between the cogni-

tive functions and job complexity are the first step in validating the use of a cognitive profile for management decisions in efficacious placement of employees.

The missing element in this study is further validation by performance ratings. The difficulty seemed to be in the range of scores. Most subjects were rated in the upper third of the performance scale; the lowest was at the 60% line. Given this restricted range, statistical analyses are less likely to detect significant relationships which might be evident over a broader spectrum of performance ratings. As it turned out, the person with the greatest mismatch between cognitive profile and job complexity received the second lowest performance rating. The highest rated persons did not necessarily have the best cognitive/complexity match, however; nor did other low-rated individuals have serious mismatches. Another statistical limitation concerns the small number of subjects at the extremes of performance ratings. Further studies of this kind will augment the sample size and increase the power of significance tests. Finally, the performance appraisals undoubtedly are based on a number of personality factors, which would be unrelated to the complexity assessed by our techniques. Again, with relatively few subjects in this study, it is not too surprising those data were not more contributory.

The concept of "hemisphericity" has become popular in some circles. Individuals are defined along a continuum from favoring verbal/sequential skills normally associated with the left hemisphere to visuospatial skills normally associated with the right hemisphere. The popularity stems from the idea that a person who is "right brained" -- performs better on tasks associated with the right hemisphere -- might be using only half of the brain. Self-help courses thrive on the notion that such a person would be helped by training the other, presumably unused, side of the brain. Validation that "right brained" people use only the right brain, or that one brain half could

be trained, is simply lacking. Even studies which show that individuals such as artists, engineers, and lawyers do have specialized cognitive preferences, also demonstrate that there is no difference in asymmetry of electrical brain activation (Arndt and Berger, 1978; Dumas and Morgan, 1975).

What, then, is valid about specialized brain skills and performance in daily endeavors? For one thing, there is face validity in the observations that those with good performance on visuospatial tasks are often artists, architects, and so forth, while those with good verbal skills are lawyers, accountants, and such. More specifically, studies have shown that good combat pilots do have the superior visuospatial skills expected of them (Gordon, 1982). Even children who have chosen special interests in model building favor visuospatial skills, while those who favor creative writing have relatively better verbal/sequential skills (Gordon, 1983). What is not valid is that the specialized abilities of these people do not necessarily imply that one hemisphere is more active than the other. The whole brain contributes to the performance of tasks. The implication is that some people are more efficient in performing specialized tasks associated with one hemisphere than the other. Accordingly, the concern of this study was not where in the brain a task is performed but, rather, how well performance on a specialized task is predictive of job success. If the specialized tasks are chosen to be the tasks that are related to special processing of the right or left hemisphere, then we have achieved a link from the rather nebulous concept of job duties and job performance to clearer and more valid notions of cognitive function of the human brain. The results have given an initial "green light" that such a link may be made, but we must proceed with caution until further confirmation is forthcoming.

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Table 1. Pearson Correlations Between Job
Complexity and Cognitive Function

	Cognitive Laterality Measures			
	A	P	CLQ	CPQ
Job Complexity Measure				
SCOPE	.49**	-.02	.47**	.29
Number of Interconnections				
Simultaneous	.43*	-.02	.41*	.25
Reciprocal	.18	.02	.15	.12
Sequential	.19	.11	.08	.18
Simultaneous and Reciprocal	.43*	-.01	.40*	.26
Simultaneous, Reciprocal and Sequential	.48**	.02	.42*	.31
Null	.15	-.23	.33	-.04

*p < .10

**p < .05

Table 2. Pearson Correlations Between Complexity of Important Items and Cognitive Function

	Cognitive Laterality Measures			
	A	P	CLQ	CPQ
Number of Interconnections				
SIMULTANEOUS				
First most important	.41*	.11	.29	.32
Second " "	.48**	.06	.39*	.33
Third " "	.48**	-.00	.44*	.30
Fourth " "	.46**	.02	.41*	.29
RECIPROCAL				
First " "	.16	.28	-.10	.27
Second " "	.22	.24	-.01	.28
Third " "	.13	.38	-.21	.30
Fourth " "	.19	.18	.02	.23
SEQUENTIAL				
First " "	.19	-.18	.32	.01
Second " "	.15	.06	.08	.13
Third " "	.21	-.09	.27	.07
Fourth " "	.18	.23	-.04	.24
SIMULTANEOUS & RECIPROCAL				
First " "	.45**	.23	.21	.41*
Second " "	.55**	.22	.32	.47**
Third " "	.51**	.23	.27	.45**
Fourth " "	.47**	.12	.33	.36
SIMULTANEOUS, RECIPROCAL AND SEQUENTIAL				
First " "	.54**	.19	.33	.45*
Second " "	.63***	.25	.36	.54**
Third " "	.60***	.20	.37	.49**
Fourth " "	.53**	.20	.32	.45**
NULL				
First " "	-.01	-.27	.22	-.16
Second " "	-.14	-.36	.18	-.30
Third " "	-.12	-.33	.17	-.27
Fourth " "	-.11	-.34	.19	-.26

* p < .10; ** p < .05; *** p < .01

Table 3. Pearson Correlations Between Index of
Complexity and Cognitive Function

	Cognitive Laterality Measures			
	A	P	CLQ	CPQ
Indices of Complexity (IC)				
Simultaneous	.34	.26	.09	.36
Reciprocal	.05	.27	.19	.19
Sequential	.11	.25	-.11	.22
Simultaneous and Reciprocal	.36	.41*	-.03	.46**
Simultaneous, Reciprocal and Sequential	.33	.45**	-.10	.47**
Null	-.41*	-.50**	.06	-.55**

 * $p < .10$

** $p < .05$

JOB TITLE:_____

Appendix A

JOB ELEMENTS

(1) List below the job elements required to perform the specific job listed above. Be as specific as possible.

(2) Rate each job element according to its importance to the total job using the Rating Scale to the right.

1 = Very minor
2 = Low
3 = Slightly below average
4 = Average
5 = Slightly above average
6 = High
7 = Extreme

1.   1 2 3 4 5 6 7

2.   1 2 3 4 5 6 7

3.   1 2 3 4 5 6 7

4.   1 2 3 4 5 6 7

5.   1 2 3 4 5 6 7

6.   1 2 3 4 5 6 7

7.   1 2 3 4 5 6 7

8.   1 2 3 4 5 6 7

Appendix B

Fill in diagram defining interconnections between job components listed on previous pages. Interconnections are defined as:

0 = No connections between elements; i.e., Element X has no effect on performing Element Y.

1 = Sequential dependence; i.e., Element X influences Element Y but not the reverse. (X→Y)

2 = Reciprocal dependence; i.e., Element X influences Element Y and, at a subsequent time, Element Y influences Element X. (X⇄Y)

3 = Simultaneous interdependence; Element X and Element Y influence each other dynamically. (X↔Y).

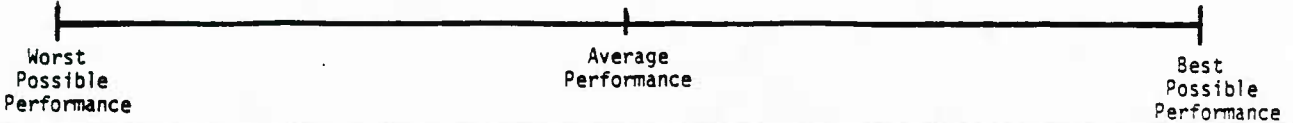|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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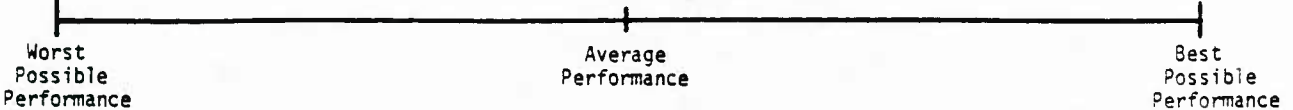
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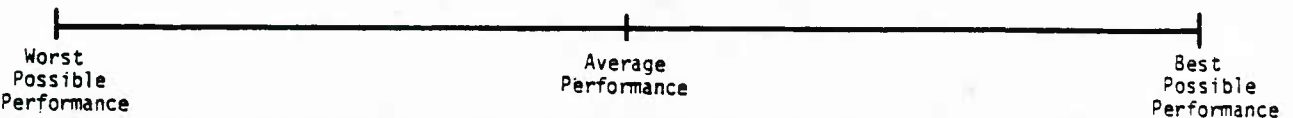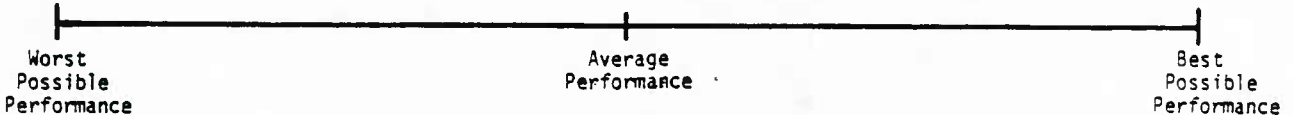
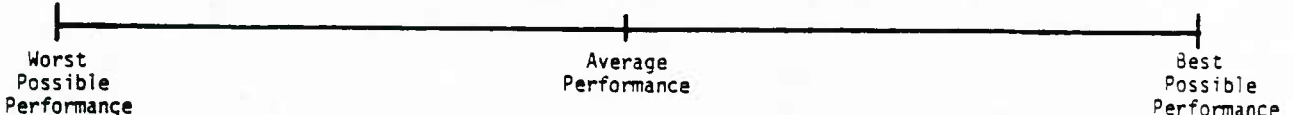JOB HOLDER: _____

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INSTRUCTIONS: Please rate the above Job Holder by putting an "X" along
the line in the location that best describes his/her
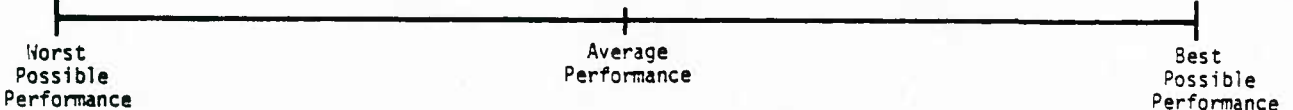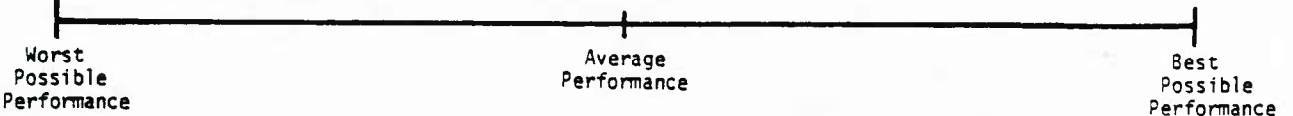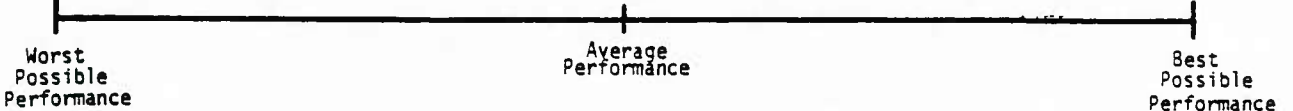performance on each individual job element.

1.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

2.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

3.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

4.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

5.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

6.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

7.

Worst	Average	Best
Possible	Performance	Possible
Performance		Performance

8.

Worst	Average	Best
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Performance		Performance

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Special Assistant for Marine
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Mr. R. Lawson
ONR Detachment
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AF AMRL/HE
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AFHRL/LRS TDC
Attn: Susan Ewing
Wright-Patterson AFB, OH   45433

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Applied Psychology Unit
Admiralty Marine Tech. Estab.
Teddington, Middlesex TW11 OLN
England

Human Factors
P.O. Box 1085
Station B
Rexdale, Ontario
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Dr. A. D. Baddeley
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Dr. Douglas Towne
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Behavioral Technology Lab
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Dr. Baruch Fischhoff
Decision Research
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